DOCUMENT RESUME

ED 165 889 PS 010 347

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TITLE Dimensional Salience and Developmental Effects Upon the Learning of Rules.
PUB DATE Apr 78
NOTE 8p.; Filmed from best available copy; Paper presented at the Biennial Southeastern Conference on Human Development (5th, Atlanta, Georgia, April 27-29, 1978)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS *Age Differences; Cognitive Processes; *Concept Formation; *Dimensional Preference; *Elementary School Students; *Kindergarten Children; *Problem Solving; Research

ABSTRACT

This study had two major purposes: to examine the effects of dimensional salience upon the learning of conjunction and disjunction rules, and to investigate an alternative to the prevailing cognitive-change accounts of developmental differences in multidimensional problem solving. The relative salience of each of four stimulus dimensions (form, color, number and position of items on cards) was assessed among 32 kindergarten, second-, and fourth-grade children. Approximately two weeks later, conjunctive or disjunctive complete rule learning problems were administered utilizing each subject's two most-salient dimensions (A and B) or each subject's most- and least-salient dimensions (A and D, respectively). As expected, conjunctive problem solving was superior to disjunctive problem solving, and developmental differences tended to be larger on the latter tasks. Problem solving on tasks with A and B relevant to solution was superior to performance on corresponding problems with A and D relevant to solution. Although developmental differences were obtained on problems with A and D relevant, no such differences were obtained with A and B relevant. The implications of these findings for a perceptual-change model of development were discussed. (Author/MP)

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Dimensional Salience and Developmental Effects upon the Learning of Rules

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Problem and Major Purposes

Several studies have demonstrated the effects of preassessed dimensional salience upon children's unidimensional problem solving. It has been demonstrated, for example, that across a wide variety of tasks such as transposition, oddity learning, concept identification, and discrimination-shifts, learning is superior when a more salient dimension is relevant to solution than when a less salient dimension is relevant.

Although the effects of dimensional salience upon a variety of unidimensional problem solving situations have now become well documented, nevertheless, the theoretical conceptualization of this variable has been limited by restricting concern to its influence upon unidimensional learning or attention. Thus, salience has been said to reflect the priority with which a given dimension is selected as a basis for responding. However, it is conceivable that dimensional salience does not, in itself, function as a selective attention mechanism but, instead, reflects the sensitivity of the perceptual system to a given dimension of difference in the environment. Dimensional salience can, thus, be conceptualized as an attribute of the perceptual system which functions in providing information for subsequent utilization by cognitive mechanisms and operations. Consequently, in the course of problem solving, a hierarchy of dimensional salience values would represent the degree to which information is evaluated by the perceptual system and made available to cognitive mechanisms for selective attention, on the one hand, and the distribution and deployment of attention across two or more dimensions, on the other.

Because the effects of salience have been primarily studied with regard to

unidimensional problem solving, the effects of salience hierarchies upon the deployment of attention across two or more dimensions, which is necessary for the solution of a variety of multidimensional problems, has not been explicated. Therefore, one of the major purposes of the present study is to elucidate the above view of dimensional salience by determining the nature and extent of its effects upon the learning of conjunctive and disjunctive rules.

The second major purpose is to investigate an alternative to the prevailing cognitive-change accounts of developmental differences on multidimensional problem solving. It is, commonly, proposed that younger children do more poorly because they either lack, or have difficulty in utilizing, a rule or cognitive structure. According to a perceptual-change model of changing salience hierarchies, however, younger children perform more poorly than older children on multidimensional tasks because it is less likely that dimensions relevant to solution are highly salient for them. If this line of reasoning is correct, then the major extant developmental differences might be attenuated when a control for relative salience is introduced (i.e., when each subject's most salient dimensions are made relevant to task solution.) In the present study this perceptual-change position is examined in the case of rule learning.

Procedure

Sixteen boys and 16 girls were selected from each of three developmental levels, kindergarten, second-, and fourth-grade.

Approximately two weeks prior to the experiment, a method of triads salience assessment procedure (as used by Odom & Guzman, 1972) was administered to each subject to determine the relative saliences of the following four dimensions: form, color, number, and position of items on cards. Briefly, this procedure involved a series of presentations, each of which contained three items. Subjects

were instructed to choose the pair of items which were "most alike". Two items contained matching values on the basis of one dimension while another pair of items represented a match on the basis of a different dimension. On the basis of the frequency of choices to each dimension during a series of such pair-comparisons a rank-order salience hierarchy involving the four dimensions was assigned to each subject. Each subject's most frequently chosen dimension (thus defined the most salient) will be referred to as Dimension A, with B being the next most salient dimension, etc.

The experiment utilized a 3 (Developmental Levels) X 2 (Rules, either conjunctive or disjunctive) X 2 (Relevant Dimensions, either A and B or A and D) completely balanced, factorial design.

Figure 1 shows an example of items used on rule learning with form and color relevant. Below each item is a pair of letters; the first letter designates the presence (P) or absence (A) of the value representing a subject's more salient dimension (e.g., square), while the second letter designates the presence or absence of the value representing the less salient dimension (e.g., blue).

Cards were presented successively, and subjects were required to place them into one of two boxes (a or b) according to the appropriate rule. (Note that current procedure differs slightly from that typically utilized in investigations of rule learning. Instead of being required to select or identify positive instances of a category defined by a rule, subjects in the current study were required to respond to all items, differential responses being determined by the particular attribute combinations represented on that trial.)

Table 1 provides an example of correct responses to items representing each attribute contingency according to conjunctive and disjunctive rules.

Results

A 3 X 2 X 2 X 4 analysis of variance (the last factor, Attribute Contingency, being a within-subjects variable) was performed upon errors to a criterion of 14 successive correct responses. Table 2 presents the number of errors according to each of the factors contained on the above analysis and a list of the significant main effects and interactions.

As can be seen from inspection of the data in Table 2, performance was (with one notable exception) generally superior among the older children. (The kindergarteners who received an AB-conjunctive task made the fewest errors of any group.) Conjunctive task performance was superior to disjunctive task performance, and a trend toward greater developmental differences on disjunctive rules than on conjunctive rules was obtained.

As predicted, superior performance was obtained with Dimensions A and B, rather than A and D, relevant to solution. Additional indication of the influence of salience upon performances is obtained from the significant effects of Attribute Contingency and the Rule X Attribute Contingency interaction. Further examination of the latter finding suggests that the differential salience of the relevant dimensions resulted in differential responding to PA and AP items on disjunctive tasks. Thus, due to the tendency toward unidimensional evaluation of a more salient dimension, subjects tended to place the AP items with the AA items, which is, of course, incorrect for disjunctive responding.

Finally, an analysis of variance performed upon trials to last error revealed significant main effects of the independent variables and, in addition, a significant Developmental Level X Relevant Dimensions interaction, $F(2,84) = 4.11$, $p < .05$. A Newman-Keuls test performed upon the Developmental Level-Relevant Dimensions subgroups revealed no significant differences between the kindergarten, second-,

and fourth-grade groups receiving an AB problem, nor was there a significant difference between any of these groups and the fourth-grade-AD group. However, among the AD groups, the kindergarteners required more trials than did the second-graders, who, in turn, required more trials than did the fourth-graders.

Conclusions and Implications

The results demonstrate that dimensional salience, as assessed by conventional procedures such as that utilized in the current study, may not only reflect the order in which dimensions are evaluated, but also the relative perceptual sensitivity and subsequent deployment of attention to those dimensions.

Although discussions of developmental differences obtained in many diverse problem solving situations have focused upon hypothesized changes in the ability of children to restrict learning to a single, relevant dimension, thereby ignoring irrelevant information during the course of problem solving, it is evident from the current data that increased selectivity is not the only developmental change. Thus, developmental differences in performance on multidimensional problems which require for solution the processing of information along two or more dimensions may not be primarily the result of either cognitive changes or the increasing efficiency with which information can be selected, as is typically proposed. Instead, failure by younger children on multidimensional problems such as those involving Dimensions A and D in the current study may be the consequence of evaluation of information along only a single highly salient dimension rather than the necessary evaluation of information from both relevant dimensions.

The obtained elimination of typically expected developmental differences in the speed of problem solving when two highly salient dimensions (Dimensions A and B rather than A and D) were relevant offers support for a perceptual-change model of development. According to this position, developmental differences in

problem solving may reflect an increase in absolute salience values with age, especially among the least salient dimensions (e.g., Dimension D). Accordingly, with increasing age and, therefore, increasing perceptual experience with many relations and dimensions in the environment, the salience of any particular dimension is likely to be greater among older children and adults. In contrast, there may be relatively few, but highly salient dimensions (e.g., Dimension A) along which younger children can evaluate and retain information. The developmental differences in problem solving might, thus, be conceptualized in terms of changing hierarchies of salience values.

If future research demonstrates that performances on other rule learning tasks, as well as on conditional discrimination, Piagetian conservation, and multiple classification tasks are better predicted by perceptual variables such as dimensional salience than by age, then a perceptual-, rather than a cognitive-, change position would seem to be more parsimonious in accounting for the major extant developmental problem solving differences.

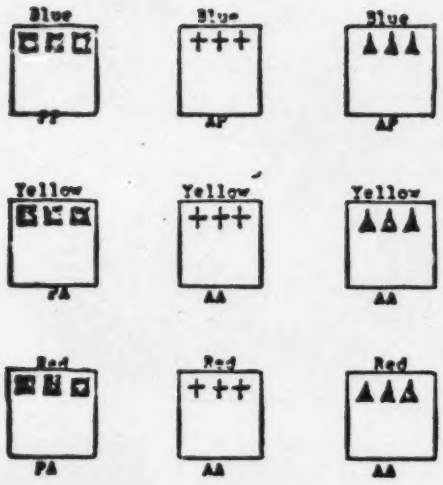

Fig. 1. Example of items used on rule learning tasks.

Table 1
An Example of Correct Responses According to Attribute Contingency and Rule

Attribute Contingency	Rule Conj	Rule Disj
PP	a	a
PA	b	a
AP	b	a
AA	b	b

Table 2

Number of Errors and Percentage of Total Errors (in parentheses) on Each Attribute Contingency According to Grade (K, 2nd, or 4th), Rule (Conjunctive or Disjunctive), and Relevant Dimensions (A & B or A & D).

		Rule			
		Conjunctive		Disjunctive	
		Relevant Dim		Relevant Dim	
Grade	Att. Cont	A&B	A&D	A&B	A&D
K	PP	15 (31)	31 (32)	8 (6)	21 (12)
	PA	13 (27)	27 (28)	32 (25)	28 (16)
	AP	15 (31)	19 (20)	33 (26)	56 (33)
	AA	6 (12)	19 (20)	54 (43)	65 (38)
	Total	49	96	127	170
2nd	PP	11 (17)	22 (23)	6 (6)	3 (2)
	PA	19 (30)	30 (32)	20 (19)	39 (30)
	AP	24 (38)	30 (32)	37 (35)	33 (26)
	AA	9 (14)	12 (13)	44 (41)	54 (42)
	Total	63	94	107	129
4th	PP	9 (15)	8 (13)	1 (1)	2 (2)
	PA	17 (28)	23 (37)	18 (25)	3 (3)
	AP	26 (43)	20 (32)	26 (36)	41 (45)
	AA	8 (13)	12 (19)	28 (38)	46 (50)
	Total	60	63	73	92

Developmental Level, $F(2,84) = 5.36$, $p < .01$
Rule, $F(1,84) = 21.52$, $p < .01$
Relevant Dimensions, $F(1,84) = 7.86$, $p < .01$
Developmental Level X Rule, $F(2,84) = 2.71$, $.05 < p < .10$
Attribute Contingency, $F(3,252) = 23.73$, $p < .01$
Rule X Attribute Contingency, $F(3,252) = 31.52$, $p < .01$